Bilkent University

Department of Electrical & Electronics Engineering

EEE-495 Electrical and Electronics Engineering Design II

Smart Greenhouse with Fruit Ripeness Control System
Final Report

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TEAM 5

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1 Introduction

1.1 Scope

The purpose of the Final Report Document is to summarize and discuss the work done during the semester for the project: Smart Greenhouse with Fruit Ripeness Control System. This report includes summary of accomplishments also, it also investigates the professional and ethical issues under a heading.

2 Purpose of the Smart Greenhouse with Fruit Ripeness Control System

Automation in agriculture is necessary as the human population keeps growing. Farmers are already using dangerous pesticides and genetically modified organics to yield enough organics to meet the huge demand. Currently, automation in farms and greenhouses helps farmers produce more food without creating a health risk for humans, which is created by the chemicals used to protect the plant. Automation in agriculture assists farmers in planting and harvesting the yield. However, in the growing process, the farmer should observe the crops so that the crop does not die. The process requires attention for each crop. Nevertheless, it is not possible to provide enough attention for each plant in large farms. Therefore, the growing process should also be automated as in planting and harvesting so that a large amount of yield can ripe without the help of harmful chemicals. [1]

For that purpose, a product called Smart Greenhouse with Fruit Ripeness Control System was designed and applied during the semester as a project. This product is to bring farmers and technology together. This purpose is done with a system which offers users to reach and control their greenhouses from their smart phones with the help of an application. With the designed application and, the established system to greenhouse, product owner may control three matters:

- Heat of the greenhouse
- Humidity of the soil
- Ripeness of the Fruit (Prototype: Tomatoes-Peppers)

3 Product Technical Specifications

Product specifications had been done parallel to Smart Greenhouse with Fruit Ripeness Control System Product Specifications Document [2]. Each feature determined in Smart Greenhouse with Fruit Ripeness Control System Product Specifications Document [2], had been applied and showed in the presentation of the product.

The product offers users 2 mode. These modes are:

- Automatic Mode
- Manual Mode

According to these modes, the working principles are differentiated by choice of the user. Firstly, a user should sign up to application. After sign up, with login page user should login the system.

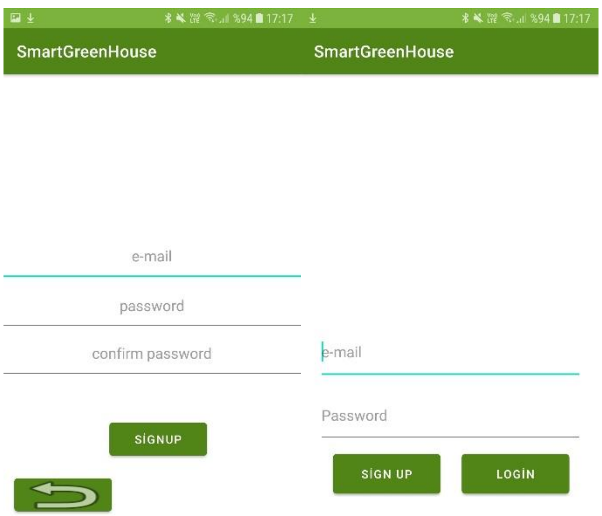

Figure 1: Signup and Login Page

After the login first time, through the application Bluetooth pairing operations should be done. First operation is pairing the product and application then sending the Wi-Fi information as firstly Wi-Fi name, then Wi-Fi password as a text.

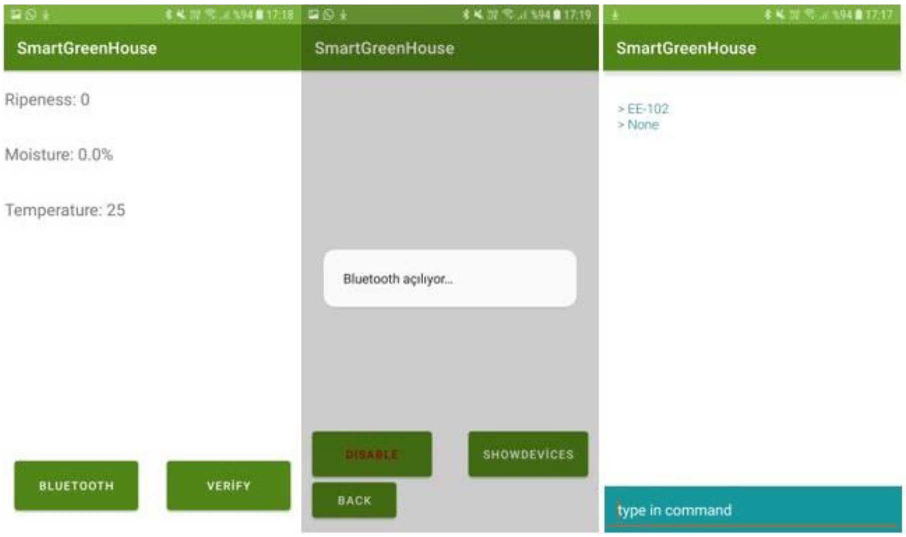

Figure 2: First Login Page- Bluetooth Operations

After connecting product to Wi-Fi, with the text comes through Bluetooth from product should be accepted and verification operation with pressing verification button should be done. This verification is done for while connecting to a device from multiple users with different accounts, to connect same product. After verification is done, application gives permission to see the temperature, moisture and ripeness information and choice of mode. In other word, without verification, users cannot use the application.

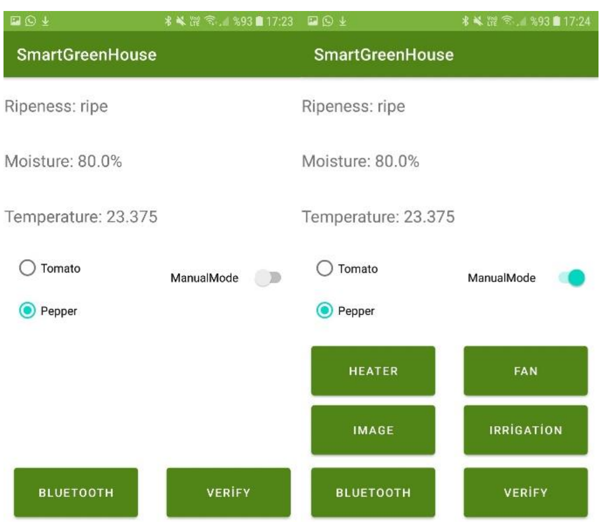

Figure 3: After Verification Operation- Auto Mode- Manual Mode

After verification, the fruit determination should be done. Also auto mode, manual mode determination can be done. After verification, user may able to see the temperature, moisture and ripeness information live.

3.1 Auto Mode Specifications

In the auto mode the optimal needed values for moisture and temperature for daytime and night for both tomato and pepper is embedded into product. Which means, when the product in auto mode, irrigation system, heater and fan is working according to values of the temperature and moisture automatically. The saved values into product for tomato and pepper are determined in the table. According to these values, operations are determined.

	Tomato		Pepper	
	Daytime (0-12 am)	Night (12-0 pm)	Daytime (0-12 am)	Night (12-0 pm)
Temperature	< 21˚C: Activate Heater > 26˚C: Activate Fan	< 16˚C: Activate Heater > 18.5˚C: Activate Fan	< 26˚C: Activate Heater > 28˚C: Activate Fan	< 16˚C: Activate Heater > 18.5˚C: Activate Fan
Moisture	< 80%: Activate Irrigation System > 95%: Deactivate Irrigation System	< 80%: Activate Irrigation System > 95%: Deactivate Irrigation System	< 9%: Activate Irrigation System > 81%: Deactivate Irrigation System	< 9%: Activate Irrigation System > 81%: Deactivate Irrigation System

Table 1: Saved optimal values for tomato and pepper and determined operations according to these values

Also, in every day, in 1pm, camera in the greenhouse takes picture of fruits. According to that picture, the ripeness of fruits is determined. For tomato, there are three options:

- Fully ripe,
- Half ripe
- Not ripe.

It shows how many tomatoes are fully, half or not ripe. On the other hand, for the pepper, there are two options

- Ripe
- Not ripe.

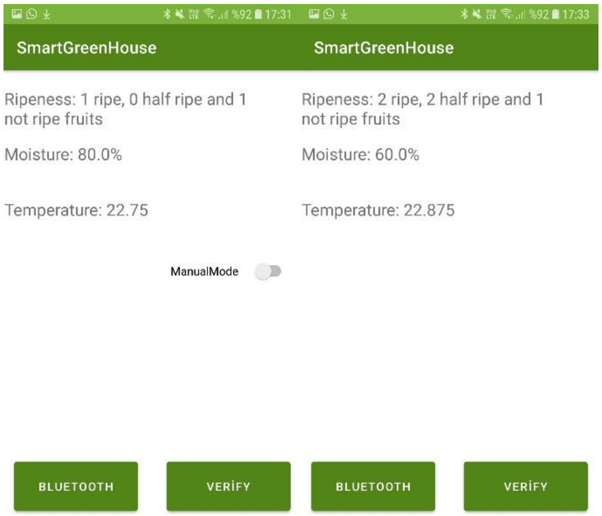

Figure 4: Ripeness of Fruit (Tomatoes)

The taken photograph can be seen in the manual mode's image section.

3.2 Manual Mode Specifications

In the manual mode, user can control the heater, fan, irrigation system directly with buttons. They may activate and deactivated the heater, fan and irrigation system. Also, with image button, they may see the picture captured from greenhouse in determined hour (1 pm) as default.

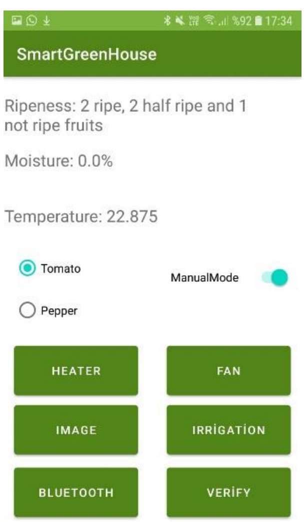

Figure 5: Manual Mode Page

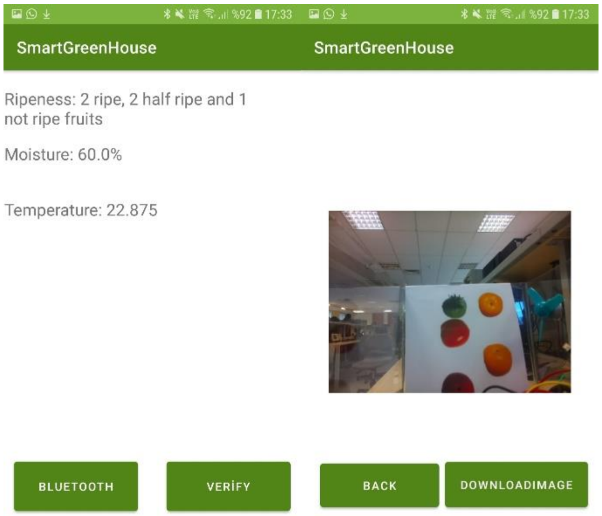

Figure 6: Example of Ripeness of Tomatoes and Photograph

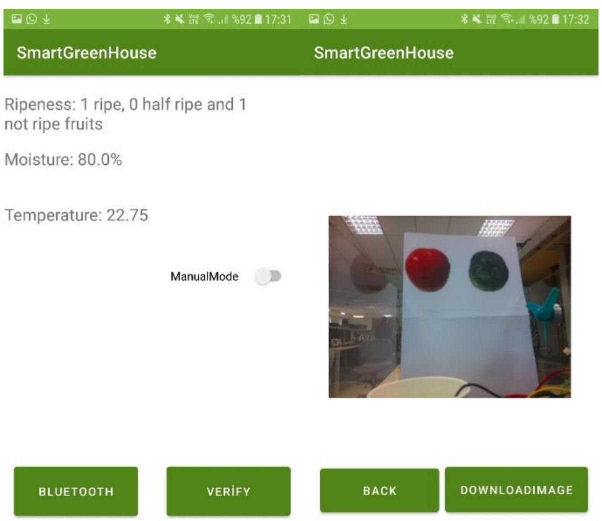

Figure 7: Example of Ripeness of Tomatoes and Photograph

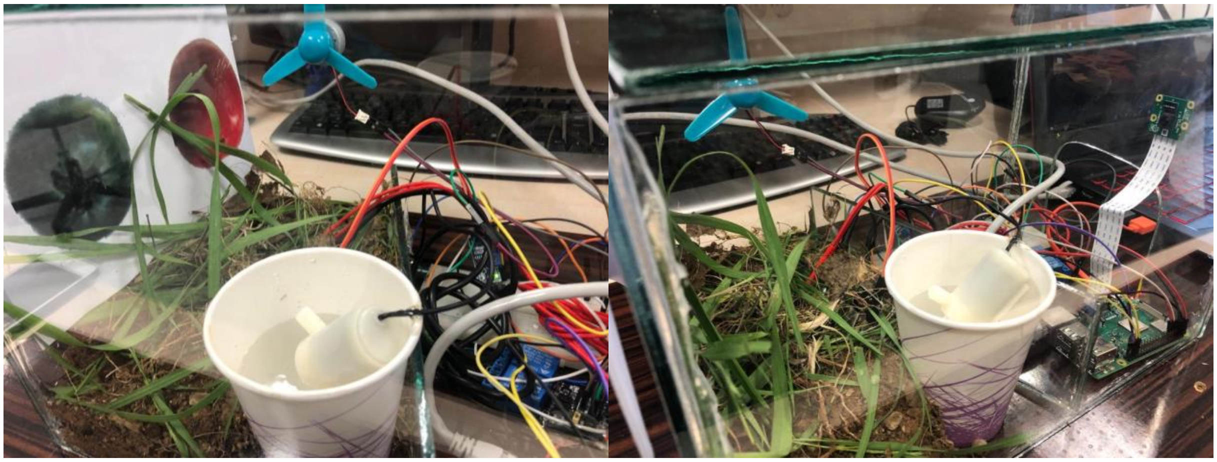

Figure 8: Pictures of Product in Prototype Greenhouse

4 Design

The hardware of the system collects the by the moisture sensor, heat sensor and camera. The Raspberry pi behaves according to data collected from these sensors. The fan and solenoid valve is activated according to the commands that come from the Raspberry. [3]

Moisture sensor helps us to understand that is there any need for irrigation. We will put in to the soil. It works by 5V and it works thanks to ADC circuit. When the water in the soil detected it sends HIGH signal to Raspberry. Thanks to I/O pins on the Raspberry we are able to understand the conditions of the soil. It uses the V_{CC} pin of the raspberry for 5V. Temperature sensor also uses same pin of the Raspberry for 5V. However, it activates the fan when the temperature of the greenhouse should be decreased or it activates the heater when the temperature of the greenhouse should be increased. The fan, heater and solenoid valve are directly connected to relays which can be activated by the signals that are send from I/O pins. On the other hand, the camera has its own pins on the Raspberry pi. It is easily activated on Raspberry pi settings. It takes pictures and videos. However, on this project we need pictures of the fruits. The camera will take the picture of the fruit at specific times according to machine learning algorithm. The pictures of the fruits will be stored and we can track the development of the fruit. [3]

The communication consists of 3 components which are the Bluetooth verification Wi-Fi verification and Wi-Fi data transfer. User should satisfy the Bluetooth component, before accessing the data. However, these components will only start to work after pi connects to the Wi-Fi and enables the Bluetooth. To save the data provided by Pi, Firebase real-time database is preferred as it is easy to implement in the application and pi. Additionally, it has a built-in account management system and its database can be structured using rules, which enables verification for the product. [3]

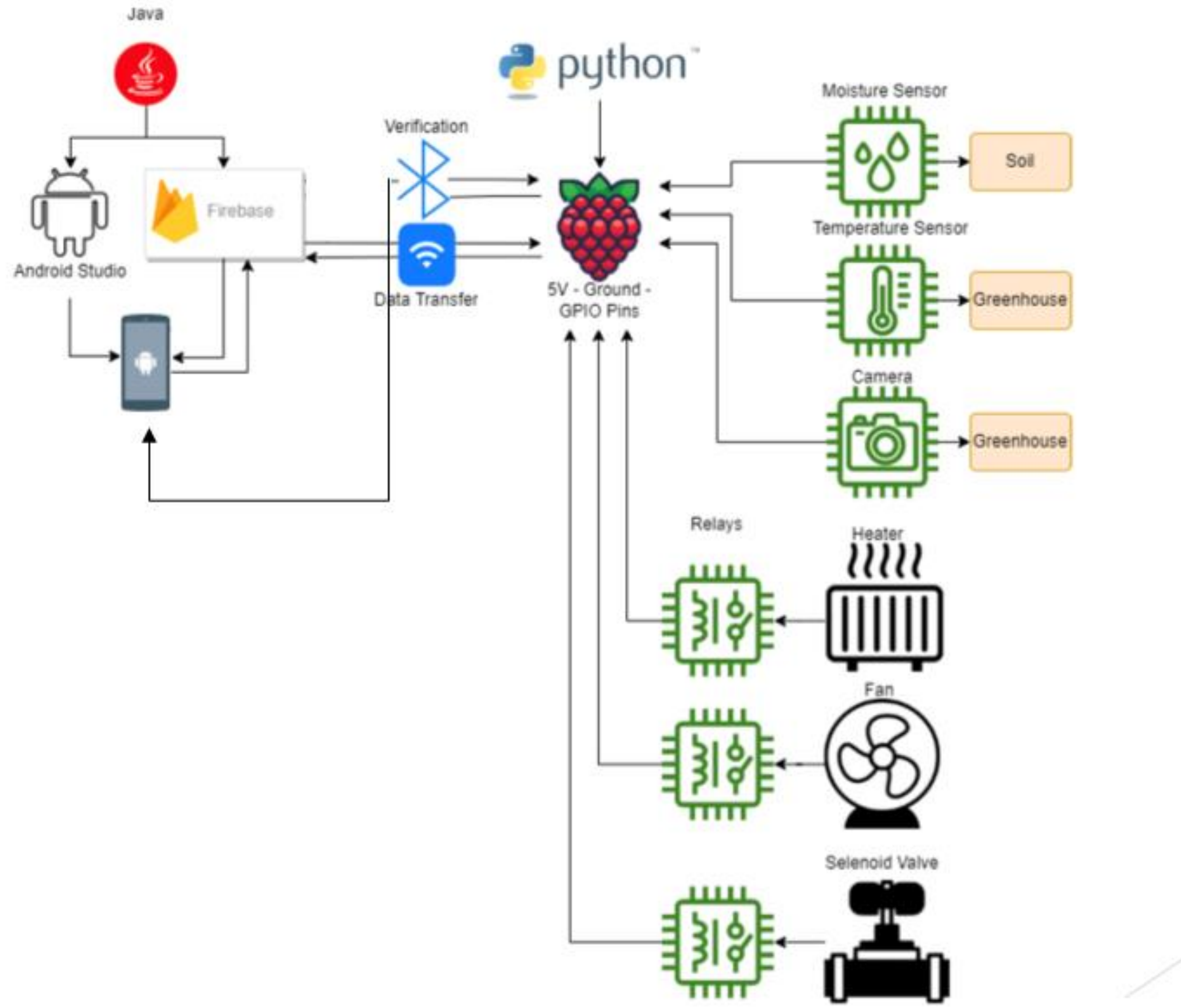

Figure 9: System Block Diagram [3]

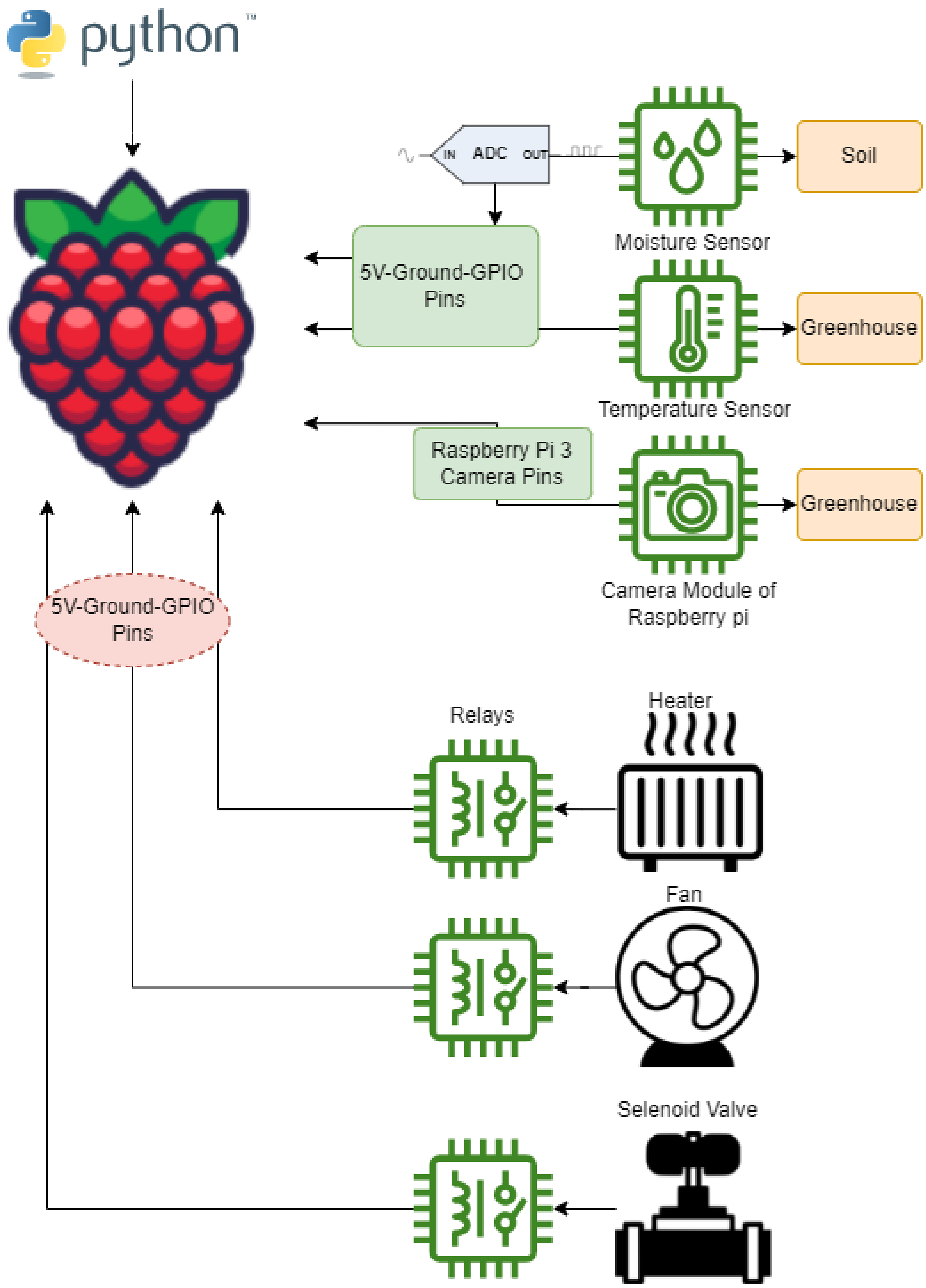

Figure 10: System Hardware Block Diagram [3]

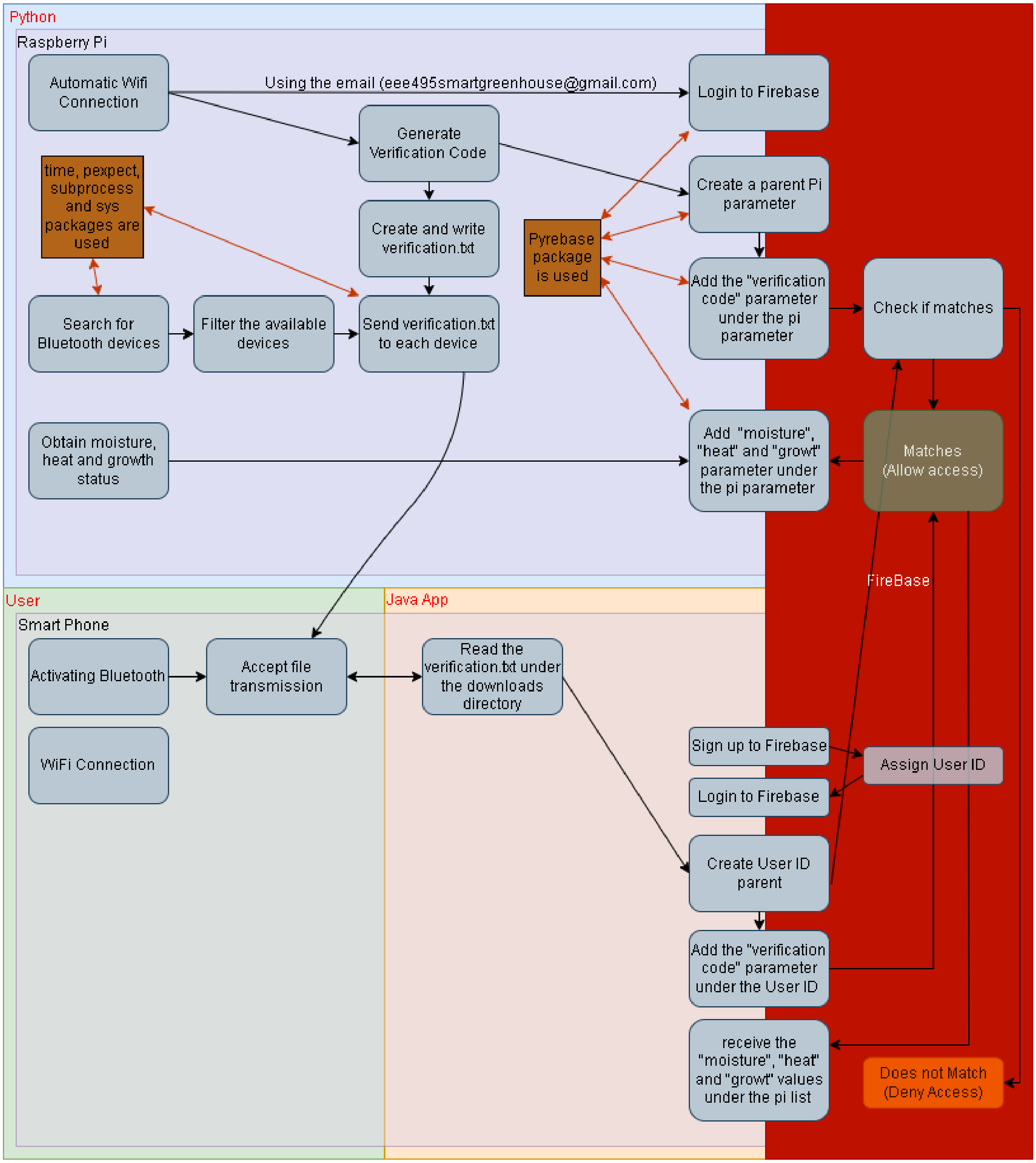

Figure 11: Detailed communication diagram [3]

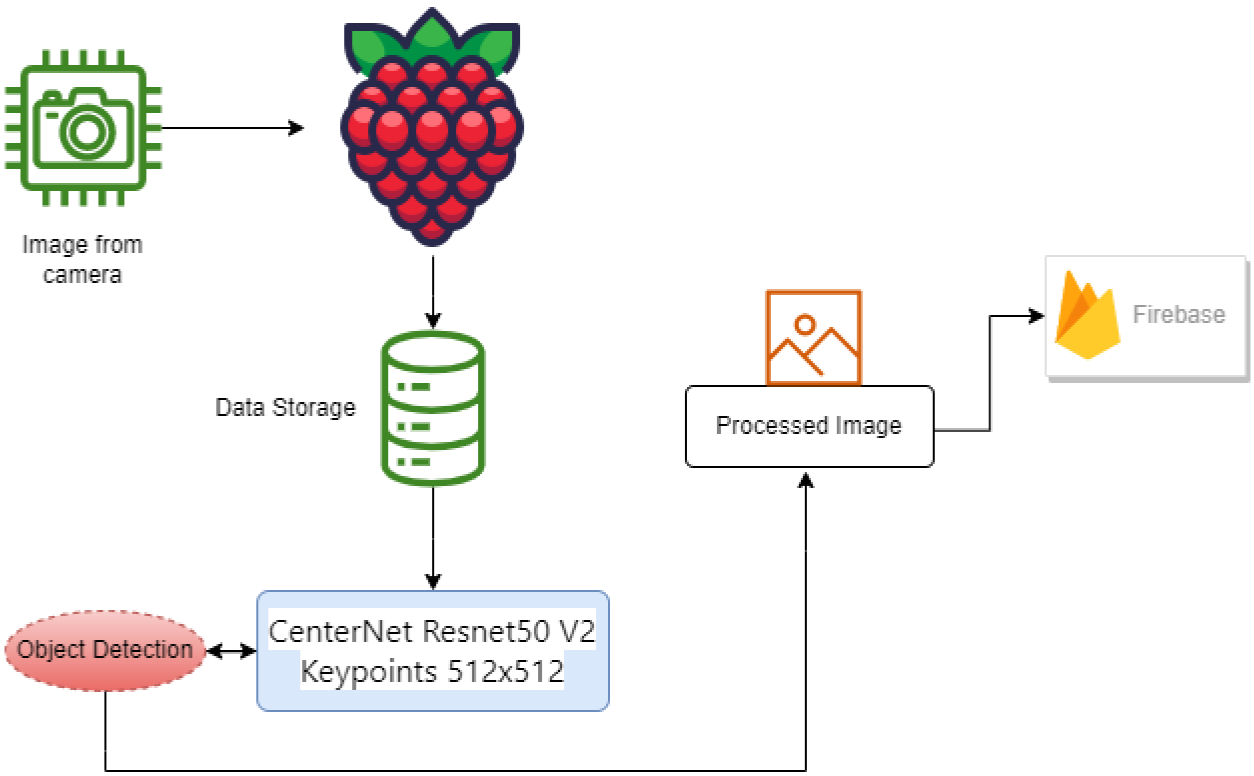

Figure 12: Image Processing Block Diagram [3]

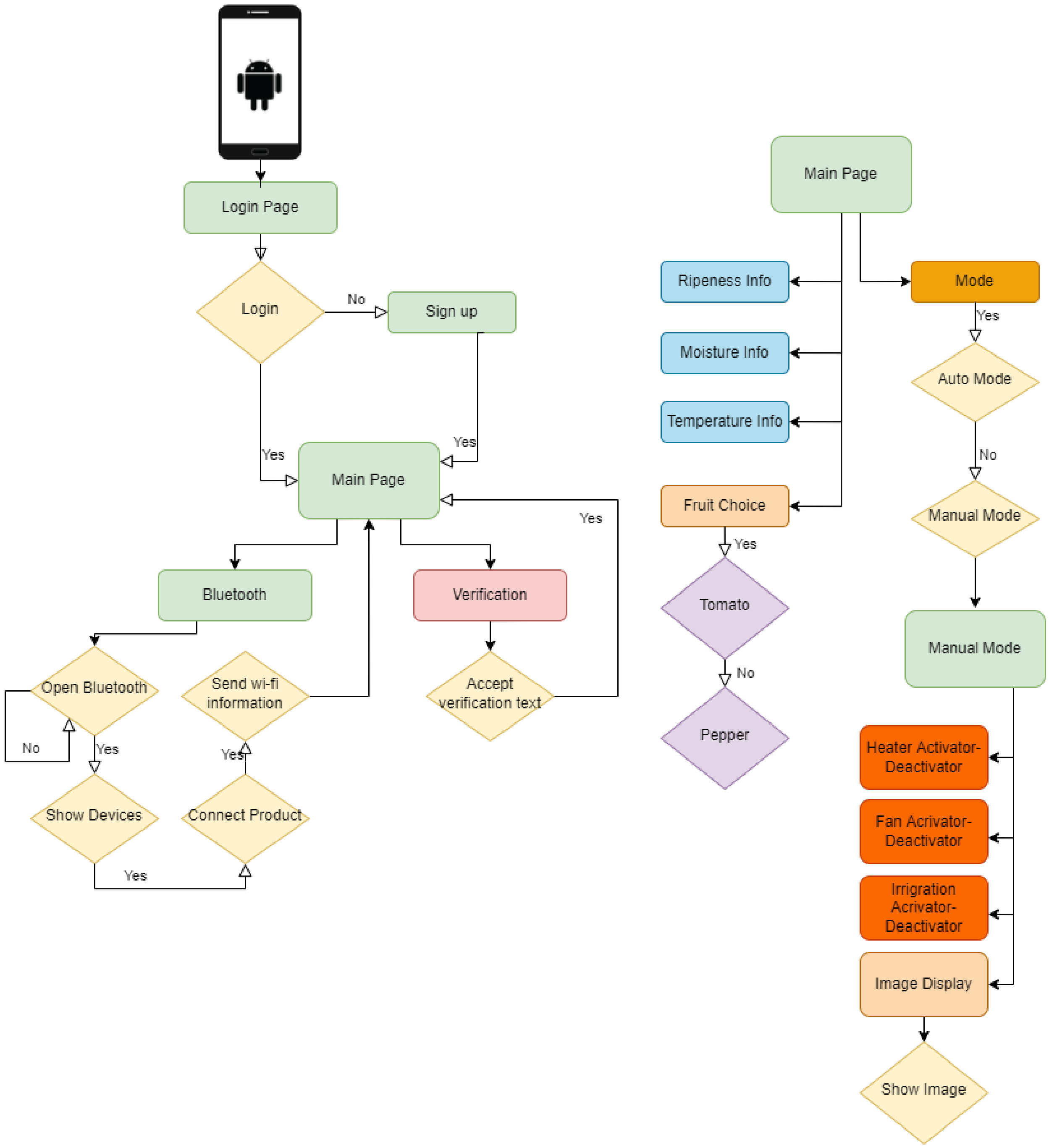

Figure 13: Android Application Block Diagram [3]

5 List of Components

Description	Cost
DS18B20 (Thermometer)	60 TL
Heater	20 TL
Water Pump	0 (Provided by University)
Moisture sensor	0 (Provided by University)
Fan	0 (Provided by University)
Raspberry Pi 3B+	0 (Provided by University)
Camera	0 (Provided by University)
Bell Glass	180 TL

Table 2: List of Component

6 Work Distribution

Cem Bingöl	Machine Learning and Image Processing
Şeyma Demirci	Android Application
Müşteba Anıl Önder	Hardware Implementation
Burak Osman Uz	Server and Communication Systems

Table 3: Work Distribution

7 Professional and Ethical Issues

In software design, other than the built-in libraries of raspberry pi and modules in base python 3.9, which allow commercial use, tensorflow-lite, pyrebase and bluetoothctl are used. Bluetoothctl is a wrapper that is used to control the Bluetooth functionalities of command prompt through python, so it is an open source and open for commercial use library. Likewise, the pyrebase library is a wrapper for firebase functions, which are executable in python. However, to use pyrebase, Firebase database should be available. In this project, a trial version of Firebase is used, nevertheless in a large scale project, the limits of the trial version won't be enough. Thus, in commercial use the Firebase database membership should be purchased. Lastly, the tensorflow is an open source and a free library, which can be used for commercial purposes. Consequently, all of these modules and libraries can be used in a large scale commercial project.

For the application, the Android Studio has been using. The codes for Android Studio, Java has been using. For the cloud, Firebase is using. In the Android Studio: "FirebaseAuth" for firebase authentication and "FirebaseDatabase" for using the data in the cloud, libraries will be used. For the intents "Intent" library will be used. For image taking "Picasso" library will be used. [3]

The hardware parts that are not designed by the project members are relays, fan, thermometer, moisture sensor, heater, water pump and camera. Initially, there aren't much information which indicates that those parts are open for commercial use. However, the camera and the thermometer are produced to be compatible with raspberry pi, which is free for commercial use. Appropriate and cheaper than raspberry pi devices should be researched in a commercial product to increase the profit. Nevertheless, currently raspberry pi and components like camera and thermometer are free for commercial use. The other parts like the fan, water pump, relays, moisture sensor and heater are used prevalently. Thus, although there is no definite information about their license, relying on the fact that they are prevalently used, they can be used in this product after purchasing each of them.

8 Conclusion

The smart greenhouse with fruit ripeness control system aimed to create an environment easing the farming. For this purpose, it had to automatically adjust the heat and the moisture. Furthermore, one of its goal was to detect the growth level of the plant and acknowledge the user about the status of the plant through mobile application. In the end, when the project was tested, raspberry successfully rebooted and started the program written. The user has signed up and logged in to the application. As expected raspberry pi created a Bluetooth rfcom server and received the wi-fi name and the password successfully through mobile device, which allowed it to connect to the internet. Later on, it sent the verification code through Bluetooth successfully and mobile application received it as expected. With the verification code the mobile application was allowed to send requests and get greenhouse status information. The greenhouse could change modes, and adjust the temperature and the moisture according to the user's demand. Furthermore, it could adjust status to the predetermined optimum values in the automatic mode. Lastly, the smart greenhouse could take a photo in 13:00 and determine the growth status of the plant using machine learning algorithms with high accuracy (for tomato). Consequently, the project has worked as expected and accomplished its tasks successfully. However, there are relatively weak points which should be enhanced. Initially, the machine learning's accuracy can be increased for both tomato and the pepper. Furthermore, the raspberry pi is not appropriate to run for long times as its heat increases quickly. This may burn the system or slow down the process, so a separate cooling unit might be necessary. Although, greenhouses allow light in, in winter the day lasts for a short time and the plant may need extra light to grow. Thus adding a light level control to the system may contribute to the growth of the plant. Eventually, this project has contributed knowledge to the group members in creating a working system from scratch. The task distribution and overcoming the incidents allowed us to learn how to manage a team and how to work together. Furthermore, this project taught us in many technical ways. The Bluetooth, Wi-Fi and database usage on both java application and raspberry pi is learned. Writing a functional and practical application on java has been learned. Creating a working machine learning algorithm on a Linux system, which is implemented on raspberry, is learned. The hardware's connection to the raspberry and its limitations are learned well. Eventually, this project has taught us how to connect all these parts and how to create a product in the end. All of these skills are obtained through overcoming the issues and trying to meet the requirements of the system. Consequently, although the project can be enhanced in the future, it accomplished its tasks successfully. It taught us well, how to manage the team and the project, and it taught us a lot about the technical side of the smart greenhouse system.

9 References

[1] C. Bingöl, Ş. Demirci, M. Önder and B. Uz, "Smart Greenhouse with Fruit Ripeness Proposal", 2022.

[2] C. Bingöl, Ş. Demirci, M. Önder and B. Uz, "Smart Greenhouse with Fruit Ripeness Control System Product Specifications Document", 2022.

[3] C. Bingöl, Ş. Demirci, M. Önder and B. Uz, "Smart Greenhouse with Fruit Ripeness Control High Level Design Document", 2022.